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FINAL REPORT

AN EPIDEMIOLOGICAL INVESTIGATION OF THE CHRONIC PEN IN A SASKATCHEWAN FEEDLOT

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Final Report

An epidemiological investigation of the chronic pen in a Saskatchewan feedlot

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Abstract

A large feedlot in central Saskatchewan was the site of the study. A total of 12,039 fall and winter placed calves were placed in this feedlot during the study period. Those calves that became chronically ill, and entered the chronic pen were intensively studied and sampled. 1.3% (158) of the total number of calves went on to become 'chronics'. Chronic calves were defined as being non-responsive to antibiotic therapy with weight loss, chronic fever and/or lameness. Treatment failures for undifferentiated fever accounted for 49%, 39% were lame with polyarthritis, and another 9.5% were lame with no evidence of polyarthritis.

3 'chronic' calves were persistently infected with BVD virus, yet they did not succumb to mucosal disease. 72% of the calves entered the chronic pen with a medium to high reciprocal titer (36 - >324) for BVDV. 78% of the calves entered the chronic pen with a high reciprocal titer (1280 - > 5120) for *Mycoplasma bovis*.

60% of 'chronic' calves were returned to their home pen after an average period of convalescence of 30 days, with an ADG of 2.4 lb. 40% of 'chronic' calves either died or were euthanized after an average period of convalescence of 15 days, with an ADG of -3.2 lb.

'Chronic' calves contributed 40% of all the calf mortality in the feedlot. 40% had both polyarthritis and chronic pneumonia on necropsy, whereas 21% had polyarthritis only. 17.5% had chronic pneumonia, and another 16% had either fibrinous pleuritis, pericarditis and/or myocarditis on necropsy.

Executive summary

A pattern of chronic disease has been recognized in fall-placed weaned beef calves in Western Canadian feedlots. Affected calves become 'non-responders' to antibiotic therapy with weight loss, chronic pyrexia and/or lameness. These calves are termed 'chronics' by both feedlot personnel and veterinarians. After numerous antibiotic treatments with no response, calves affected with this condition are moved to a 'chronic pen' for a period of convalescence.

There are essentially two objectives of this study. The first objective is to describe this pattern of chronic disease in terms of morbidity, days on feed, weight change and mortality. The second objective of this study is to determine the association between bovine virus diarrhea virus (BVDV) and *Mycoplasma bovis* infection and chronic disease in feedlot calves.

A large feedlot in central Saskatchewan was used as the site for this study. This feedlot placed 12039 weaned beef calves from Sept. 09- Dec. 12, 1998. 1.3% (158/12039) of these calves went on to become 'chronics'.

When a calf entered the chronic pen it weighed on average 124 lb. less than the projected average weight of its home pen. Even before entering the chronic pen weight loss is significant.

'Chronics' were classified into three categories based on diagnosis by a veterinarian. 49% were treatment failures for undifferentiated fever, 39% were treatment failures for lameness with polyarthritis, and another 9.5% were treatment failures for lameness with no evidence of polyarthritis. Calves who were treatment failures for undifferentiated fever or polyarthritis entered the chronic pen on average after five weeks on feed. Calves who were lame with no evidence of polyarthritis entered the chronic pen on average after 9.5 weeks on feed. Regardless

of the cause of 'chronic' disease, calves spent on average 3.5 weeks of convalescence in the chronic pen.

Only three 'chronic' calves were confirmed to be persistently infected (PI) with BVD virus. This represents only 2% of all 'chronics'. All 3 of these calves eventually returned to their home pen after a period of convalescence of 3 - 4 weeks in the chronic pen. It is of interest to note that none of these PI calves succumbed to mucosal disease while in the feedlot.

Of the calves entering the 'chronic pen' 72% had a medium to high titer for BVD, indicating recent or ongoing exposure to the virus. A 'chronic' calf was 4.5 times more likely to have polyarthritis if it had a medium to high titer to BVDV on entry to the chronic pen than a 'chronic' calf with a negative or low titer. 78% of the calves entered the chronic pen with a high titer for *Mycoplasma bovis* indicating recent or ongoing exposure to this bacteria. A 'chronic' calf with a high titer to *M. bovis* on entry to the chronic pen was 2.5 times more likely to have polyarthritis than a 'chronic' calf with a negative or low titer. It appears that both BVDV and *M. bovis* play important roles in chronic disease of feedlot calves.

'Chronic' calves were returned to their home pen if their rectal temperature was below 104° F, and they maintained or increased their body weight over a one week period and were no longer obviously lame (if applicable). Calves were euthanized in the chronic pen for humane reasons (moribund, or difficulty in rising) or for economic reasons (continual weight loss). When a calf exited the chronic pen either because it was sent back to its home pen, died or was euthanized, it weighed on average 153 lb. less than the projected average weight of its home pen. Once again weight loss is a significant feature of chronic disease in feedlot calves.

65% of the calves who entered the chronic pen due to treatment failure for undifferentiated fever eventually returned to their home pen, while 35% either died or were

euthanized. 52% of the calves who entered the chronic pen because of polyarthritis eventually returned to their home pen, while 48% either died or were euthanized. 80% of calves who entered the chronic pen because of lameness (not polyarthritis) eventually returned to their home pen, while the remaining 20% were euthanized.

'Chronic' calves were also categorized based on final outcome, i.e., did they return to their home pen or die or were euthanized in the chronic pen. 60% of 'chronic' calves were returned to their home pen after an average period of convalescence of 4.5 weeks. These calves experienced an average daily weight gain of 2.4 lb. while in the chronic pen, yet they still weighed on average 129 lb. less than the projected average weight of their home pen . 40% of 'chronic' calves either died or were euthanized after an average period of convalescence of only two weeks. In contrast, these calves experienced an average daily weight loss of 3.3 lb. while in the chronic pen, weighing on average 189 lb. less than the projected average weight of their home pen on the date of death.

Although 'chronic' calves only made up 1.3 % of the feedlot population they contributed 40% of all the calf deaths in the feedlot. Of the 'chronic' calf mortality, 40% had both polyarthritis and chronic pneumonia on necropsy, whereas 21% had polyarthritis only. 17.5% had chronic pneumonia only. A large proportion of these calves had pneumonia and arthritis lesions typical of *Mycoplasma bovis* infection. Another 16% of the dead 'chronic' calves had either fibrinous pleuritis, pericarditis or myocarditis on necropsy, lesions typically associated with *Hemophilus somnus* infection. 6% had lesions classified as miscellaneous on necropsy.

The 'non-chronic' calves contributed 60% of all calf deaths in the feedlot. If only infectious causes of death are considered (63/95 non-chronic deaths), 29% had evidence of respiratory disease on necropsy. A further, 67% had evidence of either fibrinous pleuritis,

pericarditis or myocarditis, lesions typically associated with *Hemophilus somnus* infection. 4% had lesions classified as miscellaneous. There was no evidence of polyarthritis found at necropsy among the 'non-chronic' calves.

The fatal disease onset (FDO) is the first day of treatment for an illness that eventually results in death or the day of death if a calf was never treated. The average FDO for 'chronic' calves was 15 days, whereas for 'non-chronic' calves that died of infectious diseases it was 21 days. Although 'chronic' calves became sick sooner than 'non-chronic' calves, the mean DOF at death for 'chronic' calves was 51 days and only 29 days for 'non-chronic' calves. This is probably a reflection of the different infectious causes of death between 'chronic' and 'non-chronic' calves. *M. bovis* and BVDV appear to play a large role in chronic disease whereas *H. somnus* plays a large role in the death of 'non-chronic' calves.

Technical Report

There are essentially two objectives of this study. The first objective is to describe this pattern of chronic disease in terms of morbidity, days on feed, weight change and mortality. The second objective of this study is to determine the association between BVDV and *Mycoplasma bovis* infection and chronic pneumonia and/or polyarthritis in feedlot calves.

The first part of this study is designed to answer some questions about the epidemiology of chronic disease in feedlot calves. In order to meet this objective morbidity, weight change, days on feed, and mortality data from all fall-placed calves entering a large central Saskatchewan feedlot has been collected. Affected calves become 'non-responders' to antibiotic therapy with weight loss, chronic pyrexia and/or lameness. These calves are termed 'chronics' by both feedlot personnel and veterinarians. After numerous antibiotic treatments with no response, affected calves are moved to a new pen termed the 'chronic pen' for a period of convalescence.

The first step in meeting this objective was to describe the prevalence of chronic disease in a population of fall-placed weaned beef calves in a feedlot. This feedlot placed 12039 weaned beef calves from Sept. 09- Dec. 12, 1998. 27.3% (3283) of these fall-placed calves were treated at least once for either undifferentiated fever or lameness. These are the calves at risk of becoming 'chronics'. 4.8% (158/3283) of these calves at risk or 1.3% (158/12039) of the entire population went on to become 'chronics'. Although this is a very small proportion of the feedlot population, this study shows that chronic disease results in significant production loss and mortality.

The second step was to determine the frequency distribution of the specific causes of 'chronic' calf morbidity and mortality with the number of days on feed. 'Chronics' were classified into three morbidity categories based on diagnosis by a veterinarian. 50% were treatment failures for undifferentiated fever, 42% were lame with polyarthritis, and another 5% were lame with no evidence of polyarthritis. Calves in this last category had evidence of complicated foot rot, toe abscesses or necrotic extremities. 4 calves were never examined before dying or euthanasia in the chronic pen. The mean number of days on feed (DOF) upon entering the chronic pen for each of the three morbidity categories was 35, 39, and 66 days respectively ($P<0.001$). 'Chronic' calves who were lame with no evidence of polyarthritis entered the chronic pen much later in the feeding period, suggesting a different disease process than that which causes chronic undifferentiated fever and/or polyarthritis.

"Chronic' calves were returned to their home pen if their rectal temperature was below 104° F, and they maintained or increased their body weight over one week and were no longer obviously lame (if applicable). Calves were euthanized in the chronic pen for humane reasons (moribund, difficulty in rising) or for economic reasons (continual weight loss). A routine necropsy was performed within 24 hours of death by a veterinarian.

40% (63/158) of the 'chronic' calves either died or were euthanized. In the rest of the feedlot population, only 0.8% (95/11881) of the 'non-chronic' calves died or were euthanized. Although 'chronic' calves made up only 1.3 % of the feedlot population they contributed a significant proportion (40%) of all the calf mortality in the feedlot. 'Chronics' were classified into five mortality categories based on predominant lesion(s) found at necropsy. Of the 'chronic' calf mortality, 40% had both polyarthritis and chronic pneumonia on necropsy. 21% had polyarthritis only and 17.5% had chronic pneumonia only. Another 16% of the dead 'chronic'

calves had either fibrinous pleuritis, pericarditis or myocarditis on necropsy, lesions typically associated with *Hemophilus somnus* infection. 6% had lesions classified as miscellaneous on necropsy. Regardless of the cause of mortality, the mean DOF upon entering the chronic pen was 35 days.

A large proportion of these calves had pneumonia and fibrinous arthritis lesions typical of *Mycoplasma bovis* infection. *M. bovis* has been isolated from the lungs and joints of some of these 'chronic' calves that had been submitted to a diagnostic laboratory. In addition, based on histology and immunohistochemistry many of these cases also have evidence of injury to vessels of the heart, lungs and joints that appear to be caused by BVDV infection. Morphologically, cases of chronic pneumonia often had fibrinous pleuritis and fibrous adhesions between the parietal and visceral pleura and pericardium. In cases of chronic pneumonia, typically the surface of the affected lung lobes would have areas of raised white to yellow nodular lesions resembling abscesses. Up to 70% of the lung would be consolidated with severe bronchopneumonia characterized by numerous multifocal to coalescing areas of caseous necrosis and sequestration. Of 16 chronic pneumonic lungs from calves in the convalescent pen that were submitted to the diagnostic laboratory, 13 were confirmed to be infected with *M. bovis*, via culture and/or immunohistochemistry. The remaining 3 lungs had lesions described as characteristic for *M. bovis* infection, however further diagnostic tests were not carried out. In addition, *M bovis* was cultured from the joints of 2 out 3 polyarthritic calves from the convalescent pen that were submitted to the diagnostic laboratory. The joint capsules of affected joints were thickened with flecks to chunks of fibrin clots in copious amounts of joint fluid (Figure 7). Occasionally the joint fluid was fibrinopurulent. Numerous joints often had clots of fibrin in the joint fluid, although clinically the calf may have had only one obviously swollen

joint, thus the term polyarthritis was appropriate. The association between BVDV and *Mycoplasma bovis* in chronic pneumonia and/or polyarthritis requires further study.

The 'non-chronic' calves contributed 60% (95/158) of all mortality in the feedlot. If only infectious causes of death are considered (63 deaths), 29% had evidence of respiratory disease on necropsy. A further, 67% had evidence of either fibrinous pleuritis, pericarditis or myocarditis, lesions typically associated with *Hemophilus somnus* infection. 4% had lesions classified as miscellaneous. None of the 'non-chronic' calves had evidence of polyarthritis on necropsy.

The fatal disease onset (FDO) is the first day of treatment for illness that results in death or the day of death if the calf was never treated. The mean FDO for 'chronic' calves was 15 days, whereas for 'non-chronic' calves who died of infectious diseases it was 21 days ($p = 0.002$). Although 'chronic' calves became sick sooner than 'non-chronic' calves, the mean DOF at death for 'chronic' calves was 51 days and only 29 days for 'non-chronic' calves ($p < 0.001$). This is probably a reflection of the different causes of death between 'chronic' and 'non-chronic' calves. *M. bovis* and BVDV appear to play a large role in chronic disease whereas *H. somnus* plays a large role in the death of 'non-chronic' calves.

The third step was to determine the duration of convalescence for each morbidity, mortality and final outcome category. 65 % of the calves who entered the chronic pen due to treatment failure for undifferentiated fever eventually returned to their home pen, the remaining 35% either died or were euthanized. 52% of calves who were in the chronic pen because of polyarthritis eventually returned to their home pen, while 48% either died or were euthanized. 80% of calves who were in the chronic pen because of lameness (not polyarthritis) eventually returned to their home pen, while the remaining 20% were euthanized. Regardless of the cause

of morbidity calves spent on average 25 days of convalescence in the chronic pen. When we looked at only 'chronic' calves who died, regardless of the cause of mortality, these calves spent on average 15 days of convalescence in the chronic pen. This difference becomes even clearer when calves are divided into those that return home and those who die or are euthanized. 'Chronic' calves who eventually return to their home pen spent on average 30 days in the chronic pen. However 'chronic' calves who eventually die or are euthanized spent on average only 15 days in the chronic pen ($p < 0.001$).

The fourth step was to investigate the association between weight change and success or failure in the chronic pen. When a calf entered the chronic pen it weighed on average 124 lb. less than the projected average weight of its home pen. Feedlot calves suffering from chronic disease experience significant weight loss even before entering the chronic pen.

'Chronic' calves were also categorized based on final outcome, i.e., did they return to their home pen or die or were euthanized in the chronic pen. 60% of 'chronic' calves were returned to their home pen after an average period of convalescence of 30 days. These calves experienced an average daily weight gain of 2.4 lb. while in the chronic pen. These calves weighed on average 129 lb. less than the projected average weight of their home pen on the date of return. Because these calves were not followed individually to slaughter we are unaware of the rate of compensatory gain these calves experienced.

40% of 'chronic' calves either died or were euthanized after an average period of convalescence of only 15 days. In contrast, these calves experienced an average daily weight loss of 3.3 lb. while in the chronic pen. These calves weighed on average 189 lb. less than the projected weight of their home pen on the date of death. There is little doubt that euthanasia was the correct choice given the extent and rate of weight loss in these calves.

The second objective of this study was to determine the association between BVDV and *Mycoplasma bovis* infection and chronic disease in feedlot calves. In order to determine the proportion of 'chronic' calves that were persistently infected with BVDV virus a blood sample was taken from each calf that entered the chronic pen. If the calf stayed in the chronic pen for more than two weeks another blood sample was collected. Calves that are PI with BVDV are more likely to become 'poor-doers' and end up in the chronic pen. These calves persistently infected with BVDV also serve as a source of virus infection for other calves in the chronic pen. 3 'chronic' calves were confirmed to be PI with BVDV. This represents only 2% of the 'chronic' calves. We however, do not know what the total number of PI calves in the feedlot was, as calves were not bled for BVD virus isloation on entry to the feedlot. All 3 PI calves eventually returned to their home pen after a period of convalescence of 3 - 4 weeks in the chronic pen. Interestingly, none of these PI calves succumbed to mucosal disease while in the feedlot. However because these PI calves all originated from backgrounding lots they were either shipped to other feedlots or moved to other pens for finishing and thus were lost to follow-up.

Seventy-two percent of calves entering the chronic pen had a medium to high reciprocal titer (36 - >324) for BVDV, indicating recent or ongoing exposure to the virus. 'Chronic' calves were 4.5 times more likely to have polyarthritis if they had a medium to high titer to BVDV on entry to the chronic pen than a 'chronic' calf with a negative or low titer to BVDV ($p < 0.001$). 78% of the calves entering the chronic pen had a high reciprocal titer (1280 - > 5120) for *M. bovis* indicating recent or ongoing exposure. The association between each morbidity category and *M. bovis* titer it was found that a 'chronic' calf with a high titer to *M. bovis* on entry to the

chronic pen is 2.5 times more likely to have polyarthritis than a 'chronic' calf with a negative or low titer ($p = 0.005$).

Most calves with chronic infectious disease had high titers to both BVD virus and *M. bovis* by the time they entered the convalescent pen . BVD titers due to passively derived maternal antibodies usually decline to1:32 or less by 4 – 6 months of age. In western Canada, calves destined for the feedlot are rarely vaccinated against BVD virus before arrival. Thus the BVD titers ≥ 1:54 measured in this population are very likely a reflection of recent exposure to BVD virus and not maternal antibodies or from vaccination prior to entering the feedlot. The distribution of BVD titers resembles the distribution of BVD titers seen in herds in which animals PI with BVD virus are present, i.e., most of the herd has high antibody titers. The high titers to *M. bovis* are consistent with active chronic infections.

Based on histological evidence of vascular lesions consistent with primary BVD infection in chronic pneumonia and arthritis cases from feedlot calves, an association between primary BVD virus infection and *M. bovis* has been suggested (34). Recently another study based on immunohistochemistry has shown both BVD virus and *M .bovis* concurrently in 35% of CPPS cases examined from an Alberta feedlot (Haines, Martin, Clark, Jim, Janzen, unpublished observations). Perhaps calves are predisposed to the CPPS due to a primary BVD virus infection. In an attempt to investigate the association between *M. bovis* infection and BVD infection we considered all the calves that were arthritis treatment failures to be infected with *M. bovis*. We also assumed that any titer ≥ 1:54 for BVD virus was an indication of recent exposure. Calves in the convalescent pen with titers ≥ 1:54 against BVD virus were 3 times more likely to have clinical arthritis than calves with titers < 1:54.

Presumably many of the calves that were undifferentiated fever treatment failures were also infected with *M. bovis*. However, because of our inability to differentiate the etiology of depressed and febrile calves we did not assign a specific cause in cases of undifferentiated fever treatment failure. Thus the relative risk of *M. bovis* infection in calves from the convalescent pen with BVD titers ≥ 1:54 could be higher than the reported 3, due to misclassification bias. Once again, it appears that both BVDV and *M. bovis* play important roles in chronic disease of feedlot calves.

The results of this study to date have been presented at the Western Canadian Association of Bovine Practitioner's Annual Conference, on January 22, 2000 and at the International Society of Veterinary Epidemiology and Economics in Breckenridge, Colorado on August 9, 2000. A paper is presently being submitted to the Canadian Veterinary Journal for publication. A copy of the paper and the abstract are included with this report. Data from this research was also presented at a meeting of feedlot veterinarians in Texas and will be presented at the American Association of Bovine Practitioner Meeting in South Dakota this September. Data from this project will also be used at future producer meetings in Saskatchewan such as the University of Saskatchewan Feedlot school.

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Epidemiologic features of the chronic pneumonia-polyarthritis syndrome of calves in a central Saskatchewan feedlot

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Abstract

A prospective field study was used to describe the epidemiology of the chronic pneumonia-polyarthritis syndrome (CPPS) of calves in a Saskatchewan feedlot and its association with *Mycoplasma bovis* and bovine viral diarrhea (BVD) virus. Thirty-two percent of the mortality among fall-placed calves was attributed to the CPPS, which equals the mortality attributed to hemophilosis (33%). Calves afflicted with the CPPS were non-responsive to antibiotic therapy, resulting in their placement in the convalescent pen. Of the calves diagnosed with the CPPS at necropsy, 96% were euthanized because they were either moribund, unable to rise or experiencing ongoing weight loss. Calves afflicted with the CPPS became ill earlier in the feed period ($p < 0.001$) yet died later in the feed period ($p < 0.001$) than calves afflicted with hemophilosis. Culture, immunohistochemisty and serological evidence suggested that *Mycoplasma bovis* was strongly associated with the CPPS. Serological evidence also suggested that primary BVD virus infection was also associated with the CPPS.

Introduction

Morbidity and mortality rates and their patterns are important epidemiological statistics. As quantitative descriptions of disease and time of occurrence they give major insights into etiological and pathological processes (1). Acute undifferentiated fever (AUF), previously called shipping fever or bovine respiratory disease (BRD) and hemophilosis are the most significant causes of morbidity and mortality respectively in weaned beef calves in western Canadian feedlots (1-4). Much has been published on the etiologic agents, clinical and epidemiologic features and economic costs of acute undifferentiated fever and hemophilosis in feedlot calves (1-3,5-9). There are relatively few case reports that describe the clinical and pathological features of the chronic pneumonia-polyarthritis syndrome (CPPS) that afflicts feedlot calves (10-15). However, only two studies describe some of the epidemiologic features of CPPS in western Canadian feedlot calves (6,16). Feedlot calves afflicted with CPPS are not responsive to antibiotic therapy and have weight loss, chronic pyrexia and/or lameness. Typically these calves have been diagnosed with pneumonia and/or arthritis, and after numerous antibiotic treatments with no response, are moved to a convalescent pen.

Mycoplasma bovis has often been isolated from the nasal secretions, lungs or joint fluid of calves with chronic pneumonia and/or polyarthritis (10-15, 17-22). Pneumonia and arthritis have subsequently been reproduced in experimental calves with the *M. bovis* isolates recovered from the joint fluid or lungs of naturally infected calves (17-18, 23-28). It has been hypothesized that *M. bovis* associated with acute undifferentiated respiratory tract disease subsequently spreads hematogenously from the lungs to the synovial membrane causing a severe fibrinous synovitis (26,29). Treatment failure may be due to the fibrinous reactions which are characteristic of

mycoplasmal infections (12), inappropriate selection of antibiotics for treatment of mycoplasma infections (27,30) or immune suppression due to *M. bovis* infection (31-33).

Primary bovine viral diarrhea (BVD) virus infections have recently been recognized in association with *M. bovis* infections in chronic pneumonia and polyarthritis cases (34). In addition, calves persistently infected (PI) with BVD virus, have been shown to have poor survivability in the feedlot. Up to 25% of calves PI with BVD virus do not succumb to mucosal disease, but have lesions of chronic pneumonia at necropsy (35).

There has also been circumstantial evidence that *Hemophilus somnus* may be the primary pathogen in polyarthritis of feedlot calves, in spite of positive culture of *M. bovis* from arthritic joints (3). Subsequently, some authors have categorized polyarthritis mortality together with other manifestations of hemophilosis mortality (6,9).

The primary objective of this prospective study was to describe the onset of fatal disease and mortality of the chronic pneumonia-polyarthritis syndrome (CPPS) in a population of fall-placed weaned beef calves in a large commercial feedlot. The second objective of this study was to investigate the association between two common feedlot pathogens, bovine viral diarrhea (BVD) virus and *Mycoplasma bovis* in cases of the CPPS in this same population.

Materials and Methods

This investigation was conducted in a commercial feedlot in central Saskatchewan which has a capacity of 17 000 animals. A total of 12,039 auction market-derived beef calves who entered the feedlot between Sept. 09 and Dec. 12, 1998 were eligible for inclusion in the study. Calves were of mixed beef breeds, weighing between 210 kg to 368 kg. Within 24 hours of arrival, calves were processed following a standardized protocol. All calves were uniquely identified with an eartag, branded, and received a 2 mL injection of vitamins A and D (Poten A.D, rogar/STB Inc, London, Ont), immunized with a modified-live infectious bovine rhinotracheitis (IBR) and parainfluenza-3 (PI_3) virus vaccine (Bovishield™ IBR-PI_3, Pfizer Animal Health, London, Ont), an 8-way clostridial bacterin and tetanus toxoid (Tasvax® 8, Schering Plough, Point Claire, Que) and a *Pasteurella* and *Haemophilus somnus* immunogen (Somnu-star Ph™, Biowest Inc, Saskatoon, Sask). A total of 3620 calves from 15 lots were vaccinated with a modified live IBR, PI3 and bovine viral diarrhea (BVD) virus (Bovishield™3, Pfizer Animal Health, London, Ont) rather than the IBR, PI3 product listed above. Calves were also implanted with a either a progesterone-estradiol or a testosterone-estradiol growth implant (Synovex® S or Synovex® H, Ayerst, Guelph, Ont). All bull calves were castrated immediately. Each calf was treated with topical ivermectin (0.5%) at the rate of 1.0 mL/10kg body weight (BW) (Ivomec® Pour-On, Merial Canada Inc, St Anne De Belle, Que). The rectal temperature of each calf was recorded at processing. Those with a rectal temperature ≥ 40.5°C were treated with a subcutaneous injection of tilmicosin at the rate of 10mg/kg BW (Micotil®, Provel, Division of Eli Lilly, Guelph, Ont). All other calves were treated prophylactically with an intramuscular injection of long-acting oxytetracline at the rate of 20mg/kg BW (Liquamycin LA-200, Pfizer Animal Health, London, Ont). Following processing, calves were moved to their

designated home pen, which were open-air, dirt pens of approximately 250 head capacity. Feed was medicated with chlortetracycline hydrochloride (Aureomycin®, Hoechst Roussel, St. Laurent, Que) at the rate of 325 mg/head/day for the first 56 days.

Pens were checked daily by feedlot personnel. Calves who appeared subjectively different from their pen mates (i.e., depressed, gaunt, increased respiratory rate or lame) were moved to a hospital facility for further examination. Based on clinical appearance and rectal temperature, calves were diagnosed and treated following a prescribed treatment protocol. Individual health records were maintained on the feedlot computer database (Hi-Plains System Inc., Amarillo, Texas) for all calves pulled by feedlot personnel.

The inclusion criteria for this study included three morbidity categories for calves with chronic infectious disease; treatment failure for undifferentiated fever, treatment failure for lameness due to arthritis, treatment failure for lameness due to complicated foot-rot or toe abscesses. These calves are often referred to as 'chronics' by both feedlot personnel and veterinarians, and moved to the convalescent pen. This was an easily accessible population and it was felt that calves with the CPPS would most likely be found within these three morbidity categories. All other calves with non-infectious disease that entered the convalescent pen (traumatic injuries, buller syndrome cases and chronic bloat cases) were excluded from the analysis. A detailed description of each chronic infectious disease morbidity category follows.

The case definition for undifferentiated fever (historically called bovine respiratory disease) was an appearance that was subjectively different from pen mates, the absence of clinical signs attributable to any organ system other than the respiratory system and a rectal temperature $\geq$ 40.0°C. These calves were treated with a subcutaneous injection of tilmicosin at a rate of 10 mg/kg BW (Micotil®, Provel, Division of Eli Lilly, Guelph, Ont) before being

returned to their home pen. Calves that were re-pulled by feedlot personnel and fulfilled the above criteria were classified as a first relapse of undifferentiated fever. They were treated with an intramuscular injection of trimethoprim-sulfa at a rate of 16 mg/kg BW (Trivetrin™, Schering Plough, Pointe Claire, Que), and moved to a hospital pen for re-treatment at 24 and 48 hours before return to their home pen. If the rectal temperature did not return to < 40.0° C by the third treatment of trimethoprim-sulfa, or if a calf was again re-pulled by feedlot personnel and fulfilled the above criteria, it was classified as a second relapse of undifferentiated fever. These calves were treated with an intramuscular injection of florfenicol at a rate of 20 mg/kg BW (Nuflor®, Schering-Plough, Pointe Claire, Que), and moved to a hospital pen for re-treatment at 48 hours before return to their home pen. If a calf was re-pulled for a third relapse of undifferentiated fever the calf would be classified as an undifferentiated fever treatment failure. These calves were treated with an intramuscular injection of oxytetracycline at a rate of 20mg/kg BW (Liquamycin LA-200, Pfizer Animal Health, London, Ont) and moved to the convalescent pen.

The case definition for arthritis was lameness with at least one swollen joint and no evidence of foot-rot. Calves with arthritis were treated with an intramuscular injection of florfenicol at a rate of 20 mg/kg BW (Nuflor®, Schering-Plough, Pointe Claire, Que), moved to a hospital pen for retreatment at 48 hours. If calves were still obviously lame 24 hours following the second dose of florfenicol they were classified as an arthritis treatment failure. These calves then received an intramuscular injection of oxytetracycline at a rate of 20mg/kg BW (Liquamycin LA-200, Pfizer Animal Health, London, Ont) and were moved to the convalescent pen.

The case definition for foot-rot was lameness with an obviously swollen coronary region and pastern. These calves were treated with an intramuscular injection of short-acting

oxytetracycline at a rate of 6.6 mg/kg BW (Liquamycin LP, Pfizer Animal Health, London, Ont) and an long-acting oxytetracycline at a rate of 20 mg/kg BW (Liquamycin LA-200, Pfizer Animal Health, London, Ont) and returned to their home pen. Foot-rot relapses were treated with an intramuscular injection of procaine penicillin at a rate of 30,000 IU/kg BW (Ethacillin, rogar/STB Inc, London, Ont), then moved to a hospital pen for re-treatment at 24 and 48 hours before return to their home pen. If the calf was still obviously lame it was classified as a foot-rot treatment failure. These calves then received an intramuscular injection of oxytetracycline at a rate of 20 mg/kg BW (Liquamycin LA-200, Pfizer Animal Health, London, Ont) and were moved to the convalescent pen.

In the convalescent pen there was less competition for bunk space, a shorter distance to walk to the feed bunk and water tank, and due to its close proximity to the hospital facility, calves are monitored closely by feedlot personnel.

Once a week all calves in the convalescent pen were evaluated for lameness, then weighed and further examined in the hospital facility by the primary investigator. A blood sample was collected biweekly from each calf for determination of the presence of BVD virus and for titers to *M. bovis* and BVD virus. BVD virus isolation was performed on serum samples as previously described (36). Titers to BVD virus were determined using a virus neutralization test (36) with a Singer isolate and *M. bovis* titers were determined using an indirect hemagglutination test (37). Following examination and diagnosis by the primary investigator, a calf was returned either to the convalescent pen or to its home pen or euthanized based upon the following criteria. A calf was returned to its home pen if it was alert, not obviously lame, maintained or gained body weight over the past week and had a rectal temperature < 40.0°C. A calf in the convalescent pen was euthanized for one of three reasons; if it was moribund or had

difficulty in rising or experienced continual weight loss. All calves that died within the feedlot were necropsied within 24 hours of death by the attending feedlot veterinarians. When the gross necropsy diagnosis was tentative, appropriate samples were submitted to Prairie Diagnostic Services at the Western College of Veterinary Medicine. The final necropsy diagnosis was based on the predominant lesion(s) that were deemed to have caused death or were the reason for euthanasia.

Morbidity, body weight, days on feed (DOF), serology and necropsy data for all calves with chronic infectious disease was entered into a computer database (Microsoft® Access version 2.0, Microsoft Corporation, Redmond, Wash). The morbidity data for calves with chronic infectious disease were distributed among 3 categories; (i) treatment failure for undifferentiated fever, (ii) treatment failure for lameness due to arthritis and (iii) treatment failure for lameness due to complicated foot-rot or toe abscesses. Calves who died of chronic infectious disease while in the convalescent pen were distributed among 5 categories; (i) chronic pneumonia, (ii) polyarthritis, (iii) both chronic pneumonia and polyarthritis, (iv) fibrinous pleuritis, pericarditis and/or myocarditis (lesions typically associated with *H. somnus* infection (3,38), and (v) miscellaneous. Calves who died (presumably of non-chronic disease) in their home pen or a hospital pen were distributed among 4 categories; (i) fibrinous or bronchopneumonia, (ii) fibrinous pleuritis, pericarditis and/or myocarditis, (iii) miscellaneous due to infectious disease, and (iv) miscellaneous due to non-infectious causes.

In order to determine the onset of disease, two variables were calculated; days on feed (DOF) to first treatment and fatal disease onset (FDO). DOF to first treatment was defined as the number of days between arrival at the feedlot (day 0) and the first day of treatment for either undifferentiated fever or lameness. FDO was defined as the number of days between arrival at

the feedlot and the day of first treatment for subsequent fatal disease (39). The FDO for calves that were 'sick on arrival' was day 0. The FDO for calves that were never treated before death was the number of DOF to death (40). DOF to convalescent pen entry was defined as the number of days between arrival at the feedlot and the day of convalescent pen entry. DOF to death was defined as the number of days between arrival at the feedlot and the day of death. The final outcomes for calves with chronic infectious disease were (i) death in the convalescent pen or (ii) return to the home pen after a period of convalescence.

The data was analyzed using an analytical software program (Student Edition of Statistix, Windows version 3.10, Analytical Software, Tallahassee, FL). The association between the continuous variables (FDO and DOF) and each nominal variable (morbidity, mortality and final outcome category) were assessed via a parametric one-way analysis of variance (ANOVA) or a two sample t-test. If, however, the data was not distributed normally, a non-parametric Kruskal-Wallis one-way ANOVA was employed. The association between chronic infectious disease, weight loss and death was assessed by calculating the relative risk, and the significance was tested by Pearson's chi square analysis. The association between titers for BVD, *M. bovis* and morbidity or mortality categories was also assessed by calculating the relative risk. The significance of the association was tested by Pearson's chi square analysis or Fishers' exact test.

Results

This feedlot placed 12,039 auction-market derived weaned beef calves from Sept. 09 - Dec. 12, 1998. In this group of fall-placed calves 27.3% (3283) were at risk of entering the convalescent pen because they had been treated at least once for either undifferentiated fever or lameness. One hundred and fifty-six calves had met one of the three inclusion criteria for chronic infectious disease and entered the convalescent pen. This represents 4.8% of the calves at risk or 1.3% of the entire population. These calves were classified into three morbidity categories based on a clinical diagnosis made by the primary investigator (Table 1). Fifty percent were classified as treatment failures for undifferentiated fever and 42% were classified as treatment failures for arthritis. Fifty-nine of the 66 arthritis cases had previously been treated for undifferentiated fever before it was noticed that they were also lame. Another 5% of the calves were lame with evidence of complicated foot-rot, toe abscesses or necrotic extremities. Four calves had died or were euthanized in the convalescent pen before examination by the primary investigator. Although these four calves had met the inclusion criteria described above, they were not assigned to a morbidity category nor was their data included in the statistical analysis for morbidity. Calves who eventually became treatment failures for undifferentiated fever and arthritis received their first antibiotic treatment and entered the convalescent pen earlier in the feeding period than calves that were treatment failures for other causes of lameness. There was no significant difference in the mean number of days in the convalescent pen ($p = 0.339$) for all three morbidity categories.

Calves with chronic infectious disease in the convalescent pen were also categorized based on final outcome (Table 2). Sixty percent were returned to their home pen while 40% died or were euthanized in the convalescent pen. Calves that had died or were euthanized in the

convalescent pen had stayed on average only 2 weeks in the convalescent pen compared an average of 4 weeks for calves that eventually were returned to their home pen ($p < 0.001$).

The mean weight difference between calves with chronic infectious disease and the projected average weight of their home pen on the day they entered and exited the convalescent pen was calculated (Table 2). There was no significant difference in this variable, when they first entered the convalescent pen, between the calves that eventually returned to their home pen and calves that eventually died or were euthanized ($p = 0.283$). The data from each final outcome category was then pooled. When a calf entered the convalescent pen regardless of its eventual final outcome it weighed on average 55.9 kg (CI, 59.8 to 52.0) less than the projected average weight of its home pen. This variable, however, was significantly different between the two final outcomes on exit from the convalescent pen ($p < 0.001$). A calf that was returned to its home pen weighed on average 57.8 kg (CI, 50.9 to 64.8) less than the projected average weight of its home pen. In contrast, calves that died or were euthanized in the convalescent pen weighed on average 85.5 kg (CI, 77.3 to 93.7) less than the projected average weight of their home pen.

Weight change data for the duration of the convalescent period was available for only 150 calves as some had died or were euthanized before they could be weighed. Of the calves that eventually returned to their home pen, 91 had either maintained or gained body weight and only 3 had lost body weight while in the convalescent pen. In contrast, of the calves that had died or were euthanized, 46 had lost weight while 10 had either maintained or gained body weight during this time. The relative risk of death for calves who lost body weight during their convalescent period versus calves who maintained or gained body weight was 9.5 (CI, 6.1 to 14.8) ($p < 0.001$).

Serum was collected for BVD virus isolation from 147 calves on their first examination in the convalescent pen. BVD virus was isolated from the serum of 4% (6/147) of these calves. Another serum sample that had been collected two weeks after entry into the convalescent pen was also tested for the presence of BVD virus. Only 3 of the 6 calves initially positive for BVD virus or 2% (3/147) of all calves in the convalescent pen were confirmed to be PI with BVD virus. All 3 calves that were PI with BVD virus had originated from lots that were not vaccinated against BVD virus and were eventually returned to their home pen.

Fifteen lots of calves had been vaccinated against BVD virus at processing. Serum collected from calves that had originated from these lots was not analyzed for titers against BVD virus. Therefore only 111 serum samples collected on the first examination in the convalescent pen were analyzed for antibodies against BVD virus. Figure 1 illustrates the distribution of BVD titers on entry to the convalescent pen and associated morbidity categories. Sixty-eight percent (75/111) of the calves had a BVD titer of at least 1:54, consistent with recent exposure. The relative risk of clinical arthritis for calves in the convalescent pen with BVD titers $\geq$ 1:54 versus calves with BVD titers < 1:54 is 3.0 (CI, 1.7 to 5.2) ($p < 0.001$).

Only 81 serum samples collected from calves that had been in the convalescent pen for at least two weeks were analyzed for antibodies against BVD virus. Seventeen calves had seroconverted, (i.e., had a least a 4-fold increase in titer) within the first two weeks in the convalescent pen. Sixty-five percent (11/17) of calves that had seroconverted while in the convalescent pen, had negative titers to BVD virus upon entry to the convalescent pen. Thus only 13.6% (11/81) of calves with chronic infectious disease were exposed to BVD virus for the first time while in the convalescent pen.

Serum samples from only 34 of the 62 calves that had died or were euthanized while in the convalescent pen were analyzed for antibodies against BVD virus as the remainder had originated from lots vaccinated against BVD virus or had died before a serum sample was collected. Figure 2 illustrates the distribution of BVD titers on entry to the convalescent pen and associated mortality categories. The relative risk of finding lesions of chronic pneumonia and/or polyarthritis in calves from the convalescent pen with BVD titers ≥ 1:54 against BVD virus versus calves with titers < 1:54 is 2.1 (CI, 1.2 to 3.5) ($p = 0.020$).

Serum collected from 147 calves on their first examination in the convalescent pen was analyzed for antibodies against *M. bovis*. Figure 3 illustrates the distribution of titers for *M. bovis* when calves entered the convalescent pen and associated morbidity categories. Seventy-nine percent (116/147) of the calves entered the convalescent pen with a titer ≥ 1:1280 against *M. bovis*, consistent with chronic ongoing exposure. The relative risk of clinical arthritis in feedlot calves with a *M. bovis* titer ≥ 1:1280 versus calves with a titer < 1:1280 is 2.6 (CI, 1.4 to 4.8) ($p < 0.001$).

Serum was collected from 104 calves after two weeks in the convalescent pen. Seventeen of these calves had seroconverted, i.e., had at least a 4-fold increase in titer against *M. bovis*. Forty-one percent (7/17) of the calves that had seroconverted while in the convalescent pen, had negative titers to *M. bovis* upon entry to the convalescent pen. Thus only 7% (7/104) calves with chronic infectious disease were exposed to *M. bovis* for the first time while in the convalescent pen.

Serum samples were collected from only 54 of the 62 calves that had died or were euthanized while in the convalescent pen. Figure 4 illustrates the distribution of titers against *M. bovis* on entry to the convalescent pen and associated mortality categories. The relative risk of

finding lesions of chronic pneumonia and/or polyarthritis in feedlot calves with titers ≥ 1:1280 against *M. bovis* versus calves with a titer < 1:1280 is 1.7 (CI, 1.1 to 2.7) (p = 0.031).

Of all the calves with chronic infectious disease, 40% (62/156) died or were euthanized in the convalescent pen. This is in contrast to the remainder of the fall-placed calf population, where only 0.8% (96/11883) either died or were euthanized. Although calves with chronic infectious disease made up only 1.3 % (156/12039) of the entire population they contributed 39% (62/158) of all the mortality among fall-placed calves. The relative risk of death for calves in the convalescent pen versus the remainder of the calf population was 49.2 (CI, 41.1 to 58.9) (p < 0.001).

Calves who died or were euthanized in the convalescent pen were classified into five mortality categories based on the predominant lesion(s) found at necropsy. Forty percent had both chronic pneumonia and polyarthritis, 21% had polyarthritis alone and 18% had chronic pneumonia alone at necropsy. There was no significant difference in the mean FDO, mean DOF to convalescent pen entry and mean DOF to death for these three mortality categories (data not shown). In total, 79% (49/62) of the calves that died or were euthanized in the convalescent pen had lesions characteristic of the CPPS. Another 16% of the calves had extensive fibrinous pleuritis with pleural effusion, fibrinous pericarditis and/or myocarditis, lesions typical of hemophilosis. The final 5% had lesions classified as miscellaneous on necropsy.

Morphologically, cases of chronic pneumonia often had fibrinous pleuritis and fibrous adhesions between the parietal and visceral pleural and pericardium (Figure 5). In cases of chronic pneumonia, typically the surface of the affected lung lobes would have areas of raised white to yellow nodular lesions resembling abscesses. Up to 70% of the lung would be consolidated with severe bronchopneumonia characterized by numerous multifocal to coalescing

areas of caseous necrosis and sequestration (Figure 6). Of 16 chronic pneumonic lungs from calves in the convalescent pen that were submitted to the diagnostic laboratory, 13 were confirmed to be infected with *M. bovis*, via culture and/or immunohistochemistry. The remaining 3 lungs had lesions described as characteristic for *M. bovis* infection, however further diagnostic tests were not carried out. In addition, *M bovis* was cultured from the joints of 2 out 3 polyarthritic calves from the convalescent pen that were submitted to the diagnostic laboratory. The joint capsules of affected joints were thickened with flecks to chunks of fibrin clots in copious amounts of joint fluid (Figure 7). Occasionally the joint fluid was fibrinopurulent. Numerous joints often had clots of fibrin in the joint fluid, although clinically the calf may have had only one obviously swollen joint, thus the term polyarthritis was appropriate.

Calves that died in their home pen or a hospital pen contributed 61% (96/158) of all mortality among the fall-placed calves. Total mortality in the fall-placed calf population along with mean FDO and mean DOF to death associated with either fatal hemophilosis, the CPPS or acute BRD is illustrated in Table 3. Calves who died or were euthanized because they were debilitated with fibrinous pleuritis, pericarditis and/or myocarditis contributed 33% (52/158) of the total calf mortality in this feedlot. Eighty-one percent (42/52) of the fatal hemophilosis cases had died or were euthanized in either their home pen or a hospital pen. Ten of these cases were never treated with antibiotics before they were found dead in their home pen. The mortality rate due to *M. bovis* infection in the form of the CPPS is equal to that of hemophilosis in this feedlot. Calves who died or were euthanized because they were debilitated with chronic pneumonia and/or polyarthritis contributed another 32% of the total calf mortality in this feedlot. Ninety-eight percent (49/50) of the fatal CPPS cases had died or were euthanized in the convalescent pen. Calves who died from acute fibrinous or bronchopneumonia contributed only 11% of the

total calf mortality in this feedlot. Six of the fatal acute BRD cases were never treated with antibiotics before they were found dead in their home pen.

Calves that died of miscellaneous non-infectious diseases such as frothy bloat, water belly, atypical interstitial pneumonia, intestinal accident, fractures, CNS tumor and exsanguination contributed 20% to the total calf mortality. The final 4% had lesions classified as miscellaneous due to infectious causes.

The mean FDO for calves who died of acute BRD and the CPPS was significantly earlier in the feeding period than the mean FDO for calves who died of hemophilosis ($p < 0.001$). The mean DOF to death for calves who died of acute BRD was significantly earlier in the feeding period than the mean DOF to death for calves who died of hemophilosis, which was also significantly earlier than the mean DOF to death for calves who died of the CPPS.

Discussion

The CPPS is a unique syndrome, different from hemophilosis and acute bovine respiratory disease. Calves afflicted with the CPPS in this feedlot were non-responsive to antibiotic therapy with chronic pyrexia and/or lameness and weight loss. After numerous antibiotic treatments with no response, affected calves were moved to a convalescent pen. Treatment for pyrexia associated with either respiratory disease and/or septicemia preceded most cases of clinical arthritis in this study. This is in agreement with several case reports that also describe outbreaks of non-responsive arthritis in calves that previously or concurrently were experiencing pyrexia and/or respiratory disease (10-15,20-22).

This is the first report that quantifies the onset of disease and mortality associated with the CPPS in feedlot calves. The majority of calves diagnosed with the CPPS at necropsy had been euthanized while in the convalescent pen, therefore the onset of disease and morbidity of all cases of chronic infectious disease that went through the convalescent pen was also described. Calves who eventually become treatment failures for undifferentiated fever or arthritis were first noticed ill approximately 2 weeks into the feeding period. However, they were not moved to the convalescent pen until approximately 3 weeks after their first antibiotic treatment. In the intervening time period, from first treatment to convalescent pen entry, many affected calves had lost a considerable amount of body weight. A calf with chronic pyrexia and/or arthritis that was non-responsive to antibiotic treatment typically weighed 56 kg less than the estimated weight of its pen mates on the day it entered the convalescent pen.

Recovery from chronic infectious disease is prolonged. Two-thirds of the calves who were treatment failures for undifferentiated fever eventually were returned to their home pen, while only a little more than half of the calves who were treatment failures for arthritis were

returned to their home pen. These calves spend on average 4 weeks in the convalescent pen and most had either maintained or gained body weight before being returned to their home pen. In contrast, one third of the calves that were treatment failures for undifferentiated fever died or were euthanized in the convalescent pen, while a little less than half of the calves that were treatment failures for arthritis met this same fate. Calves that eventually died or were euthanized spend on average only 2 weeks in the convalescent pen and most lost body weight during this time period. In fact, calves that lost body weight while in the convalescent pen were 9.5 times more likely to die or be euthanized than calves that maintained or gained body weight while in the convalescent pen. The results of this study and a retrospective study that investigated body weight change as an indicator of treatment success (41), suggest that body weight gain or loss could be used as another objective criteria along with rectal temperature to assess recovery from illness in a feedlot.

Many calves with chronic infectious disease do not die, rather they linger in the convalescent pen until they are euthanized. In fact 95% of the death loss in the convalescent pen was a result of euthanasia. Of all the mortality attributed to the CPPS, only 4% (2/50) died, one in the convalescent pen and one in a hospital pen, the remaining 96% (48/50) were euthanized because they were either moribund, unable to rise or were continually losing body weight. The chronic pneumonia and polyarthritis lesions found on necropsy were pathognomonic for *M. bovis* infection (15). In addition, *M. bovis* infection has been confirmed either by culture or immunohistochemistry from every suspected CPPS case submitted to the diagnostic laboratory. The onset of fatal disease was significantly earlier in the feed period for calves that died with the CPPS than it was for calves that died with hemophilosis. In contrast, the time of death was much

later in the feed period for calves that died with the CPPS than it was for calves that died with hemophilosis.

The CPPS is an economically important syndrome in the feedlot. The mortality rate due to the CPPS equals that due to hemophilosis. Calves who died or were euthanized because they were debilitated with the CPPS contributed one-third (32%) of the total mortality in this large commercial feedlot. Another one-third (33%) of the death loss was attributed to fibrinous pleurititis, pericarditis and/or myocarditis, lesions attributable to hemophilosis.

In spite of infrequent culture of *H. somnus* from the joints of polyarthritic calves, Van Donkersgoed (3) suggested that it may be the pathogen in cases of polyarthritis, based on the similar FDO for polyarthritic calves, with other pathognomonic manifestations of hemophilosis, specifically myocarditis and fibrinous pleuritis. The results of this study show that the FDO of polyarthritis cases is no different from the FDO of chronic pneumonia cases that have lesions pathognomonic for *M. bovis* infection, as well as being culture and/or immunohistochemistry positive for *M. bovis*. When total mortality is considered the onset of fatal disease was significantly earlier and the mean DOF to death was significantly later in the feed period for calves that died with the CPPS than it was for calves that died with hemophilosis. Evidence from this study, i.e. timing of disease and culture results, would suggest that *H. somnus* is not a primary pathogen in cases of fatal feedlot polyarthritis. In addition, a recent study based on immunohistochemistry has shown *M. bovis* and/or BVD virus to be the only pathogens found in the synoviae of feedlot calves with chronic nonresponsive polyarthritis. (Haines, Martin, Clark, Jim, Janzen, unpublished observations).

Taylor et al., (35) suggested that persistent infection with BVD virus should always be considered in calves with ill-thrift or chronic respiratory disease. However in this study, only 2%

(3/147) of the calves in the convalescent pen were PI with BVD virus. In addition, there was no evidence of mucosal disease in the 3 PI calves and all were eventually returned to their home pen. This study suggests that calves PI with BVD virus are not contributing directly to the CPPS, however they still are the source of infection for primary BVD virus cases (42).

Most calves with chronic infectious disease had high titers to both BVD virus and *M. bovis* by the time they entered the convalescent pen (Figures 1 and 3). BVD titers due to passively derived maternal antibodies usually decline to1:32 or less by 4 – 6 months of age (43,44). In western Canada, calves destined for the feedlot are rarely vaccinated against BVD virus before arrival. Thus the BVD titers ≥ 1:54 measured in this population are very likely a reflection of recent exposure to BVD virus and not maternal antibodies or from vaccination prior to entering the feedlot. The distribution of BVD titers in Figure 1 resembles the distribution of BVD titers seen in herds in which animals PI with BVD virus are present, i.e., most of the herd has high antibody titers (42). The high titers to *M. bovis* are consistent with active chronic infections.

Based on histological evidence of vascular lesions consistent with primary BVD infection in chronic pneumonia and arthritis cases from feedlot calves, an association between primary BVD virus infection and *M. bovis* has been suggested (34). Recently another study based on immunohistochemistry has shown both BVD virus and *M .bovis* concurrently in 35% of CPPS cases examined from an Alberta feedlot (Haines, Martin, Clark, Jim, Janzen, unpublished observations). Perhaps calves are predisposed to the CPPS due to a primary BVD virus infection. In an attempt to investigate the association between *M. bovis* infection and BVD infection we considered all the calves that were arthritis treatment failures to be infected with *M. bovis*. We also assumed that any titer ≥ 1:54 for BVD virus was an indication of recent

exposure. Calves in the convalescent pen with titers ≥ 1:54 against BVD virus were 3 times more likely to have clinical arthritis than calves with titers < 1:54.

Presumably many of the calves that were undifferentiated fever treatment failures were also infected with *M. bovis*. However, because of our inability to differentiate the etiology of depressed and febrile calves we did not assign a specific cause in cases of undifferentiated fever treatment failure. Thus the relative risk of *M. bovis* infection in calves from the convalescent pen with BVD titers ≥ 1:54 could be higher than the reported 3, due to misclassification bias.

In the feedlot, mortality is easier to diagnose without controversy than morbidity because a specific cause of mortality can be determined with far greater accuracy than a specific cause of morbidity (39). In spite of a small sample size (34 calves) the serological evidence also showed an association between BVD virus infection and chronic pneumonia and/or polyarthritis (lesions typically due to *M. bovis* infection) at necropsy. Calves with BVD titers ≥ 1:54 were 2.1 times more likely to have lesions of the CPPS than calves with titers < 1:54 against BVD virus.

An antemortem diagnosis of mycoplasmosis is difficult. The clinical disease often develops insidiously, takes a chronic course and is easily confused with other bacterial or viral infections. Most bacterial infections respond to antibiotic therapy with improvement in the clinical condition. Thus the failure of sick cattle to respond to treatment when pneumonia and arthritis are occurring simultaneously or when arthritis is a sequelae to pneumonia, suggests *M. bovis* infection as a differential diagnosis (20,45). *M. bovis* should be susceptible to antibiotics which act on bacterial protein synthesis (46) such as the primary antibiotics used to treat undifferentiated fever and/or arthritis in this feedlot (tilmicosin, florfenicol, trimethoprim sulfadoxine and oxytetracycline). Results of this study suggest otherwise. Perhaps because our present management and treatment of feedlot calves has effectively controlled BRD, the CPPS is

merely a 'left-over' disease. Due to the fibrinous nature of the reaction to *M. bovis* infection, once clinical arthritis appears antibiotic therapy is probably of little value. Therefore, a protocol that prevents or treats the mycoplasmemia would seem to have the most promise for the prevention of the CPPS. There is a need for controlled field trials to investigate antimicrobial protocols for the prevention of CPPS in feedlot calves.

Another potential option for the control of the CPPS in the feedlot is vaccination. Presently, there are no *M. bovis* vaccine products available in Canada. However, two studies have shown vaccination with *M. bovis* bacterins provided protection against pneumonia and arthritis in calves with experimental challenge (47,48). Because *M. bovis* is an important cause of the CPPS syndrome, further evaluation of immunization agents for its control is warranted. In addition, because of the association between BVD virus and the CPPS, field trials to evaluate the use of currently available BVD vaccines to control the CPPS is warranted.

Recovery from the CPPS is prolonged and most calves are eventually euthanized. As mentioned above, 96% of all CPPS cases were euthanized because they were either moribund, unable to rise or were continually losing body weight. Calves afflicted with the CPPS do not die within the same time period as calves afflicted with hemophilosis. They become sick sooner, however they die later in the feeding period. Presumably the mean DOF to death would be considerably longer if calves with the CPPS were allowed to deteriorate until death ensued. One of the roles of the feedlot veterinarian is to monitor animal welfare management and set criteria for euthanasia. In this study, calves were euthanized either for humane reasons, i.e., they were moribund or had difficulty in rising, or for economic reasons, i.e., they were experiencing continual weight loss. Slaughter for salvage of CPPS cases is often not a viable option due to chronic pyrexia and extended antibiotic withdrawl. In addition, by the time many of these calves

have reached the period of antibiotic withdrawl they are so debilitated it would be inhumane to send these calves to slaughter as condemnation of part or the whole carcass would be a likely outcome. Many of these calves also weigh less than 320 kg and many abattoirs in western Canada are not set up to slaughter calves of this size.

This study has shown that the CPPS is a unique syndrome in western Canadian feedlot calves, different from acute BRD and hemophilosis. One third of the death loss in this feedlot was attributed to the CPPS, which equals the death loss attributed to hemophilosis. The CPPS is also an important syndrome because it represent a significant economic loss for feedlots in western Canada due to increased antibiotic useage, reduced weight gains and increased risk for mortality. In addition to *M. bovis*, serological evidence suggests that BVD virus may play an important role in this syndrome. And finally, management of calves with the CPPS has illustrated the need to monitor animal welfare and develop criteria for euthanasia in the feedlot.

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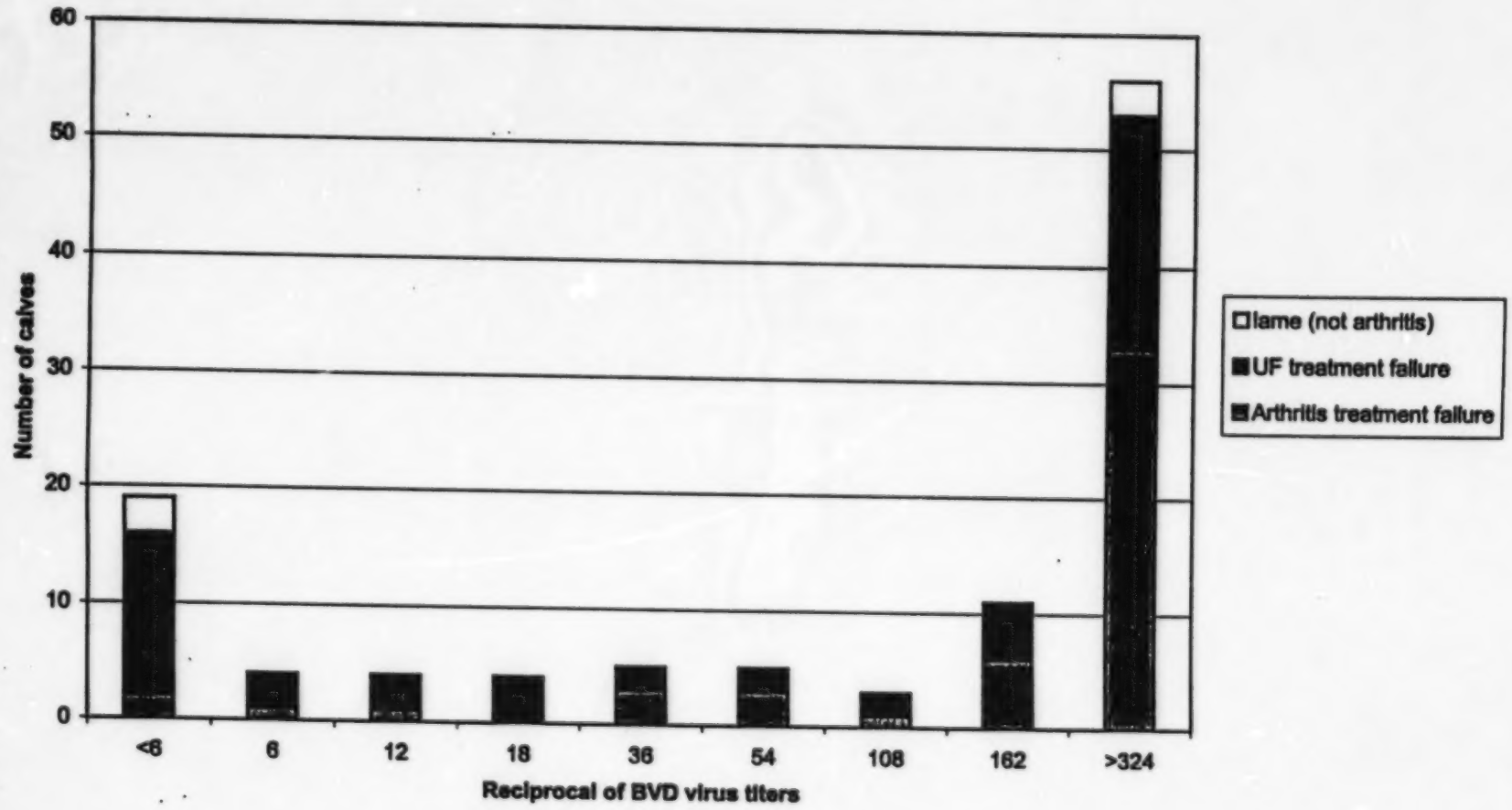

Figure 1. Distribution of BVD virus titers upon entry to the convalescent pen and associated morbidity categories.

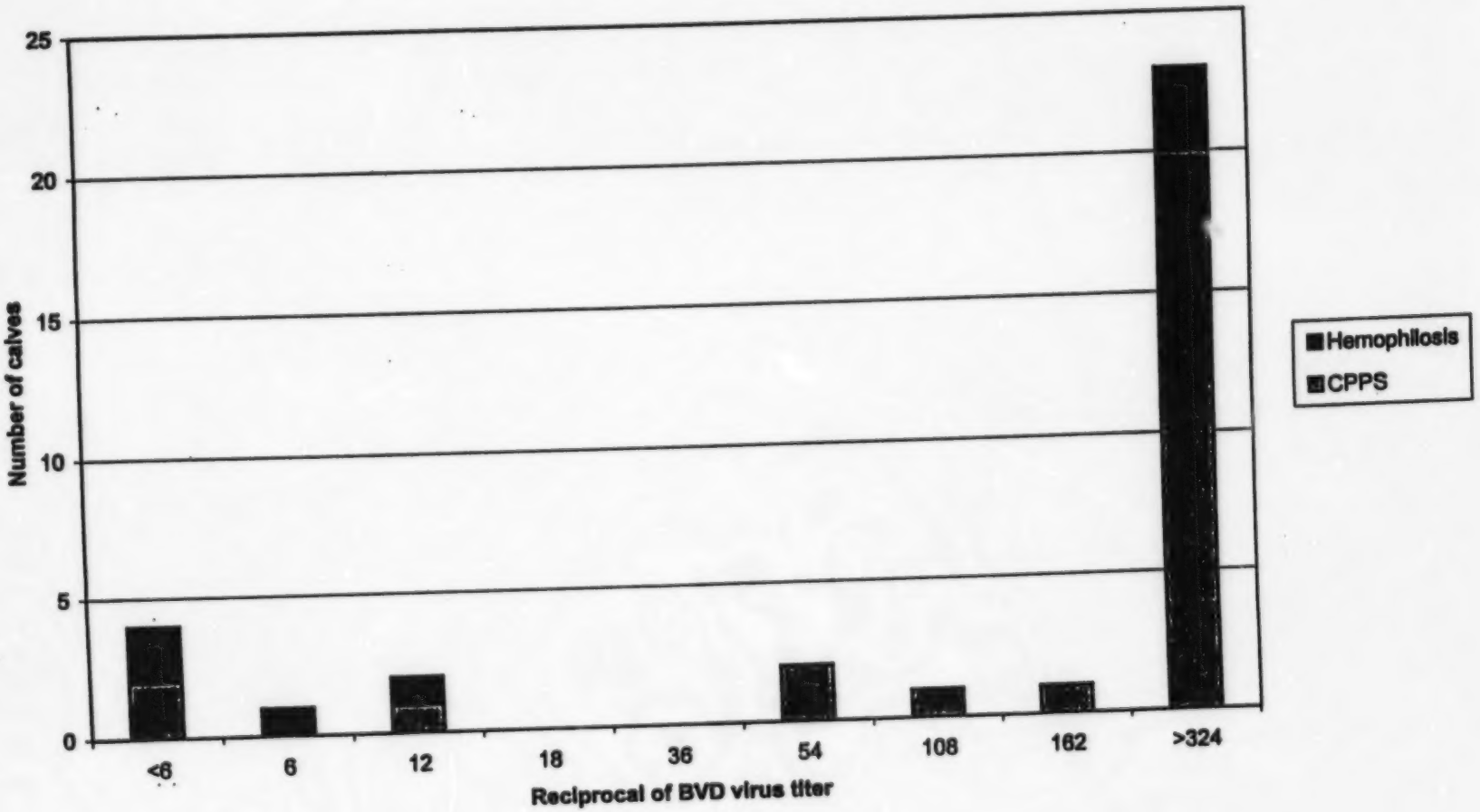

Figure 2. Distribution of BVD virus titers upon entry to the convalescent pen and associated mortality categories.

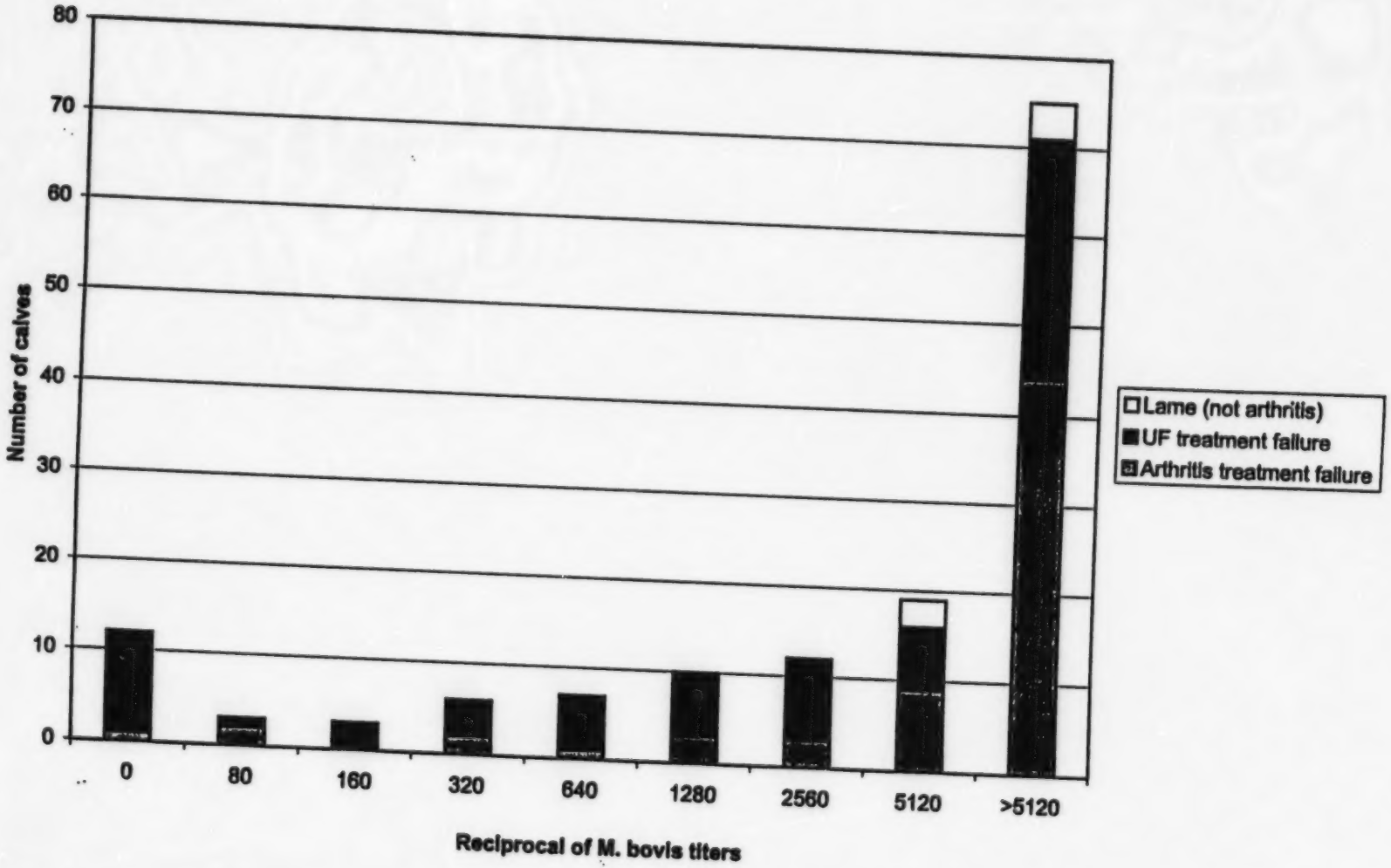

Figure 3. Distribution of *M. bovis* titers upon entry to the convalescent pen and associated morbidity categories.

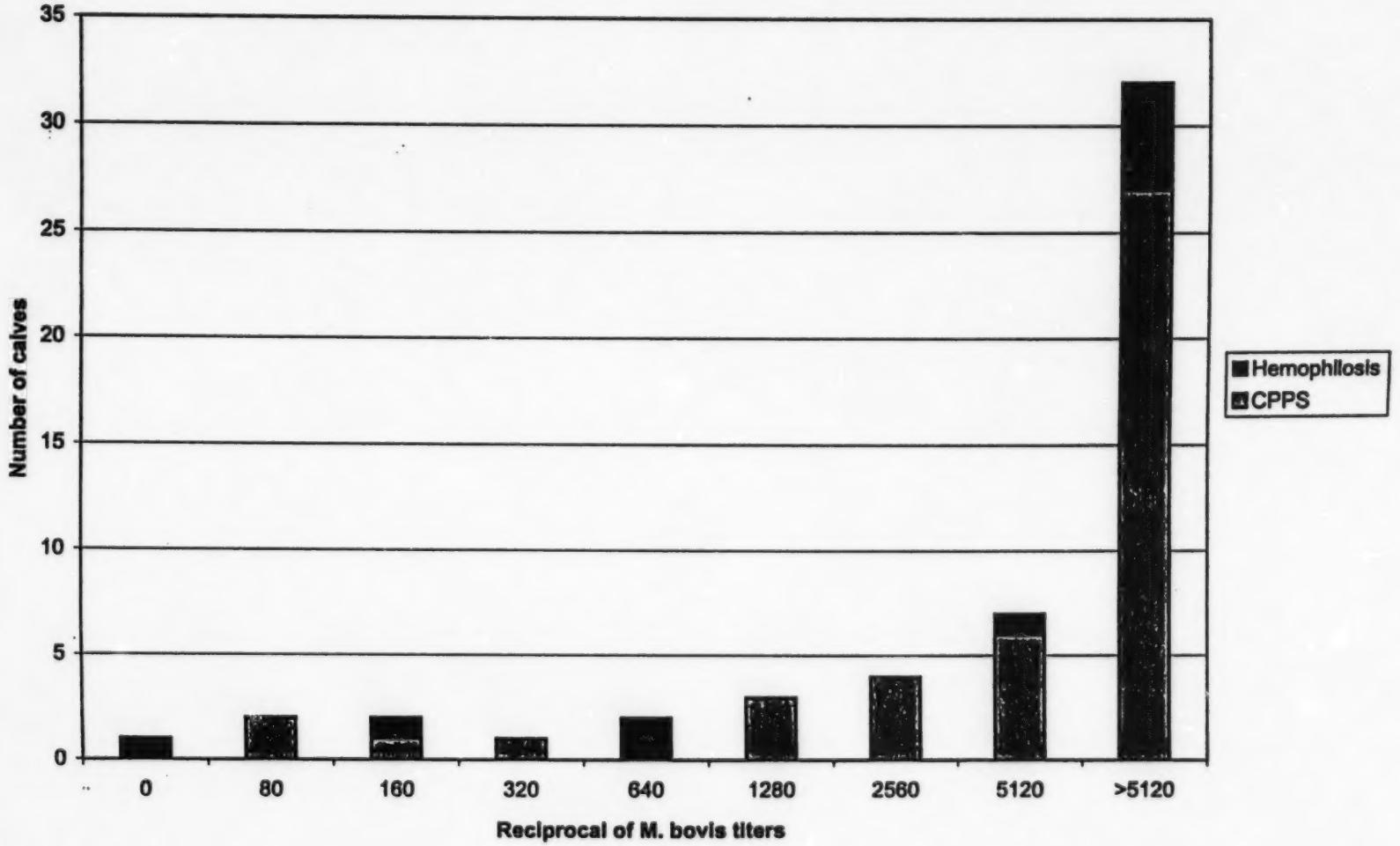

Figure 4. Distribution of *M. bovis* titers upon entry to the convalescent pen and associated mortality categories.

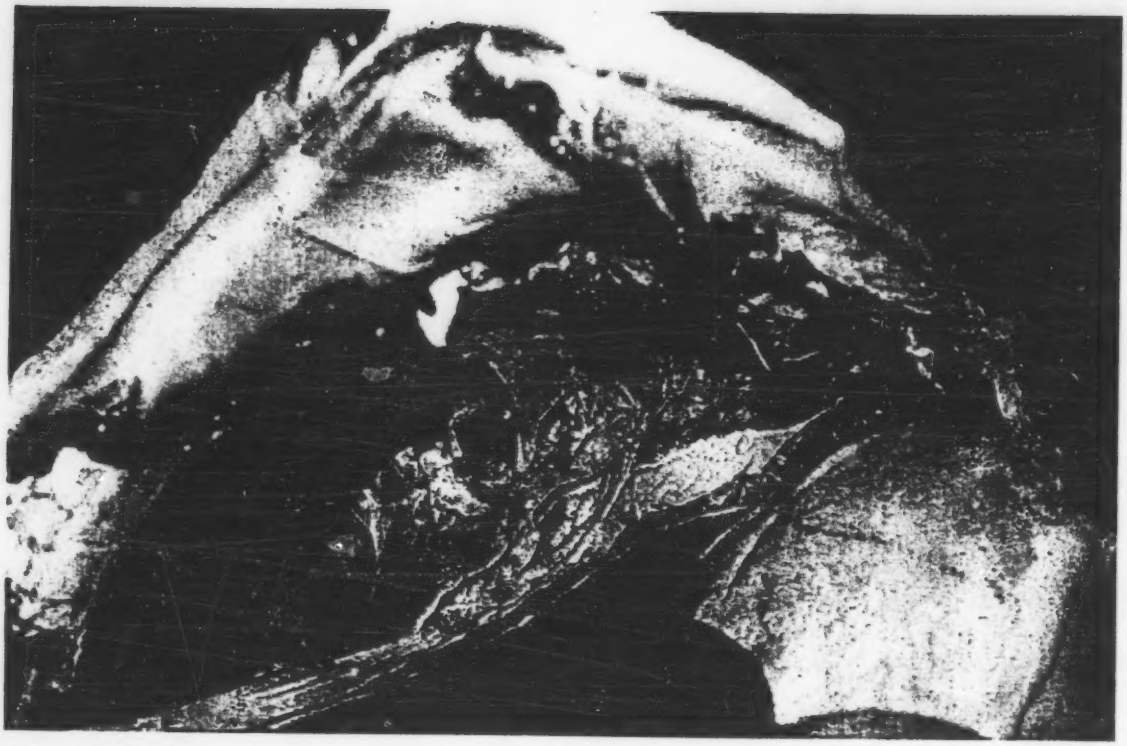

Figure 5. Chronic pneumonia with fibrinous pleuritis and fibrous adhesions between the parietal and visceral pleural, typical of the CPPS.

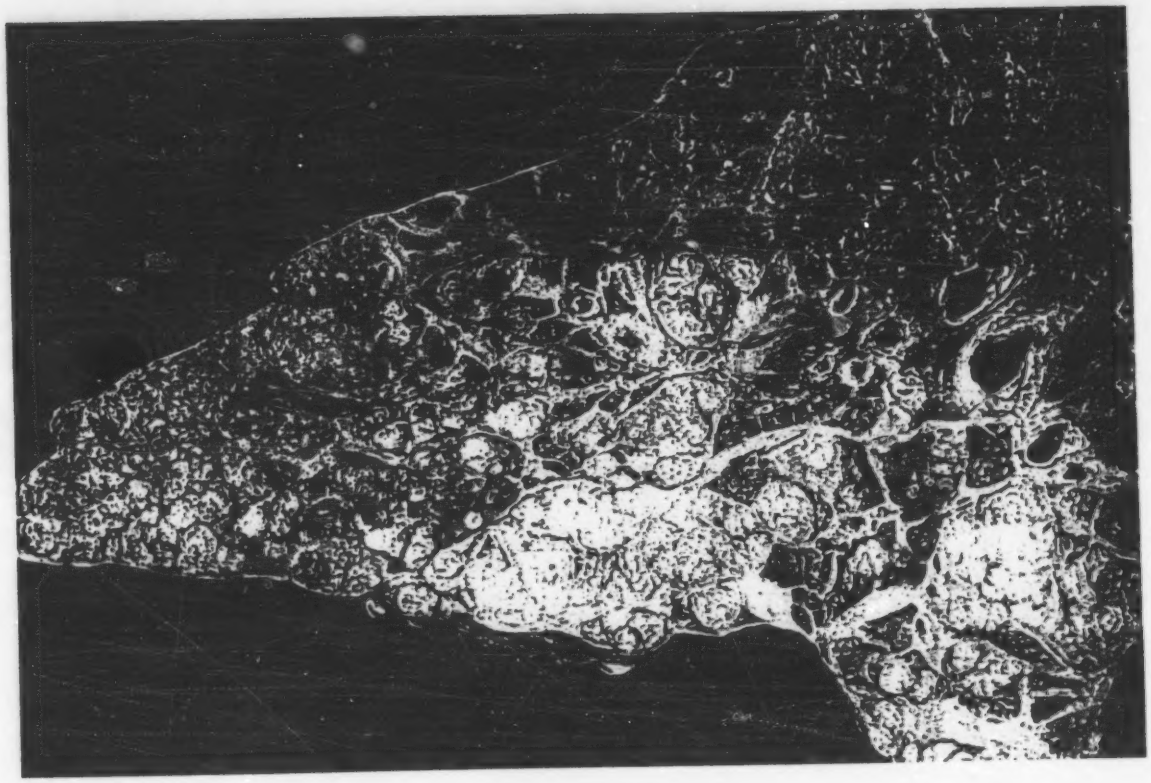

Figure 6. A section from a chronic pneumonic lung with areas of raised white to yellow nodular lesions, multifocal to coalesing areas of caseous necrosis and sequestration. *M. bovis* was cultured from this lung.

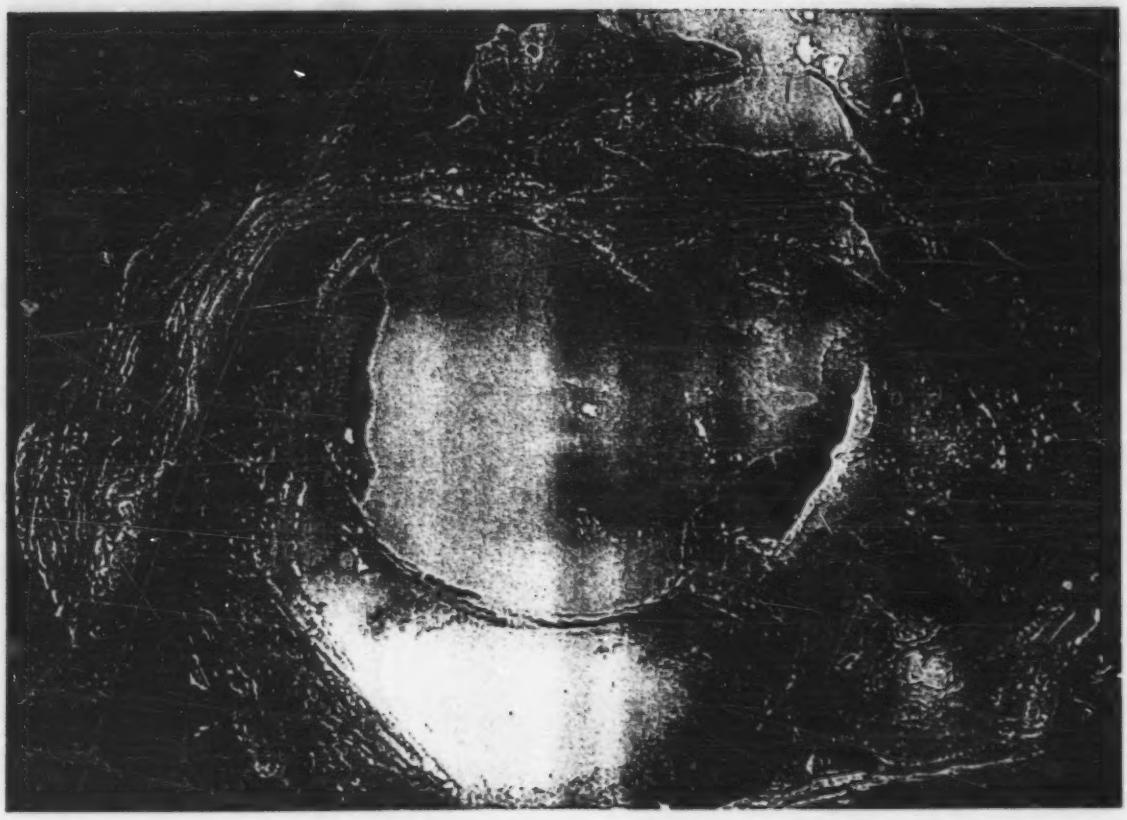

Figure 7. Fibrinous arthritis. *M. bovis* was cultured from the joint fluid.

EPIDEMIOLOGICAL FEATURES OF THE 'CHRONIC PNEUMONIA-POLYARTHRITIS SYNDROME' OF CALVES IN A WESTERN CANADIAN FEEDLOT

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Much has been published on the epidemiological features of acute undifferentiated fever and hemophilosis in western Canadian feedlot calves. However there remains little published on the epidemiological features of chronic infectious disease, specifically the chronic pneumonia-polyarthritis syndrome (CPPS) of feedlot calves. In general terms, feedlot calves afflicted with CPPS have been recognized as 'non-responders' to antibiotic therapy with weight loss, chronic pyrexia and/or lameness. After numerous antibiotic treatments with no response, affected calves are moved to a convalescence pen. The objective of this study was to describe the onset of disease and mortality associated with the CPPS in a population of fall placed weaned beef calves in a large commercial feedlot. Historically, at this feedlot, most calves with lesions of CPPS at necropsy have been euthanized while in the convalescence pen, therefore the time of onset of disease and morbidity of all cases of infectious disease that went through the convalescence pen were also described. The second objective of this study was to investigate the association between bovine viral diarrhea (BVD) virus, *Mycoplasma bovis* and *Haemophilus somnus* and the CPPS in this population of feedlot calves. The results of this study will be discussed.